DOCUMENT RESUME

ED 172 800 IR 007 434

AUTHOR Lamberski, Richard J.; Roberts, Dennis M.
TITLE Efficiency of Students' Achievement Using Black/White and Color Coded Learning and Test Materials.
PUB DATE 7 Mar 79
NOTE 13p.; Paper presented at the Annual Convention of the Association for Educational Communications and Technology (New Orleans, Louisiana, March 7, 1979); For related document, see IR 007 416

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cardiovascular System; College Students; *Color Presentation; *Illustrations; Individualized Instruction; *Instructional Aids; *Intermode Differences; Media Research; *Visual Perception
IDENTIFIERS *Black and White Presentation

ABSTRACT

The purpose of this study was to compute and analyze descriptive indices of efficiency assessing the relative effectiveness of a verbal and visual color code applied to self-paced learning and testing materials. The sample consisted of 176 college subjects randomly assigned to one of four treatment conditions receiving black/white (B) or color coded (C) materials: B learning and testing materials, or C learning materials but B testing materials. These materials consisted of a 21-page learning booklet on the human heart and an 80-item test measuring different levels of cognitive knowledge; content was identical except that in some treatment conditions a color code having meaningful physical form and associative value was applied. Subjects read through the learning booklet followed immediately by a test; six weeks later the identical test was administered to assess delayed retention. Time on learning and time on tests were recorded. Data indicated that while color coded learning materials facilitated achievement, additional time for acquisition and for retrieval was necessary. This primary relationship, in addition to secondary relationships, was discussed in light of each efficiency derivation. A list of references and several tables and graphs are attached. (Author/RAO)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED172800

Efficiency of Students' Achievement Using Black/White and Color Coded Learning and Test Materials

Richard J. Lamberski
Director-University Media Services
Assistant Professor -Educational Media and Technology
Boston University

and

Dennis M. Roberts
Associate Professor- Educational Psychology
The Pennsylvania State University

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Research and Theory Division
Association for Educational Communications & Technology
New Orleans, Louisiana
Wednesday- March 7,1979

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Michael Simonson

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

IR007434

Efficiency of Students' Achievement Using
Black/White and Color Coded Learning and Test Materials

Abstract

The purpose of this study was to compute and analyze descriptive indices of efficiency assessing the relative effectiveness of a verbal and visual color code applied to self-paced learning and testing materials. The sample consisted of 176 college subjects randomly assigned to one of four treatment conditions receiving black/white (B) or color coded (C) materials: B learning and testing materials, B learning materials but C testing materials, C learning and testing materials, or C learning materials but B testing materials.

Materials consisted of a 21 page learning booklet on the human heart and an 80 item test measuring different levels of cognitive knowledge; content was identical except that in some treatment conditions a color code having meaningful physical form and associative value was applied. Subjects read through the learning booklet followed immediately by a test; six weeks later the identical test was administered to assess delayed retention. Time on learning and time on tests was recorded.

Calculation of three related efficiency formulas (achievement per unit of time) provided the descriptive data for discussion. Data indicated that while color coded learning materials facilitated achievement, additional time for acquisition and for retrieval was necessary. This primary relationship, in addition to secondary relationships, was further discussed in light of each efficiency derivation.

Efficiency of Students' Achievement Using
Black/White and Color Coded Learning and Test Materials

Purpose and Rationale

Research during the instructional media era of the 1950's and 1960's was comparative in nature (Torkelson, 1978) and sought to identify device usefulness rather than to identify the parameters impacting on elements of the message (Dwyer, 1972; 1978). Questions posed were to justify using media rather than to optimize learning. It was this later need to investigate those message design elements which in combination or limitation may facilitate optimal (effective and efficient) learning that this study sought to supply additional evidence for. Specifically this investigation sought to clarify the cognitive value of color when used as a coding device in the design of self-paced learning and testing materials.

In surveying the color literature researchers (Lamberski, 1972; 1979; Berry, 1974; Chute, 1978) have concluded that the significance of color as a design variable has typically eluded researchers who have attempted to define its unique role rather than its possible interrelated role in the learning process. In many studies the use of color was often superseded by other variables or not properly isolated by experimental design to assess its effectiveness.

Exploratory investigations in cognitive learning have found that color may facilitate or inhibit learning when used as an instructional cue or code in message design (Kauffman and Dwyer, 1974; Lamberski, 1975; Berry, 1975; 1976). While there is support for the affective preference for color and for the physiological and developmental influence of color, it is evident that the cognitive value of color to the learning process must be clarified further (Dwyer, 1978; Lamberski, 1979). Thus, the purpose of this study was to compute and analyze descriptive indices of efficiency

assessing the relative effectiveness of a verbal and visual color code applied to self-paced learning and testing materials. It was hypothesized that when both learning and testing materials utilized a color code, learning would be most efficient (greatest performance or achievement per unit of time).

Method

Sample

The sample consisted of 176 (39 male and 137 female) student volunteers from an instructional media course at The Pennsylvania State University.

Instructional Materials

The learning material (Dwyer and Lamberski, 1977) was a revision of a 2,000 word prose text, with accompanying simple line drawing visualization and verbal labels, originally published by Dwyer (1972). The content of the material consisted of the parts and internal processes of the human heart. Two versions of the 21 page learning booklet were developed; one was entirely black/white (B) while the other one had a color code (C) applied.

The color code was applied only to relevant (central) concepts or functions being presented on a particular page with no color coding when the concept or function was redundant (peripheral) to other instruction being presented. The color code application in the booklet was for both the verbal instruction (the ink color of the printed concept or function word) and accompanying visual illustration (the identical ink color of the printed concept or function label, arrow, and shaded area). The six colors and black formed categories which related similar concepts and functions or discriminated between the other concept or function words. Thus, the color code had both a physical form (visual with cues) and an associative value (verbal with

meaning). Such a color code application has been applied in various primary reading investigations (Hinds and Dodds, 1968), and more recently color visualization has been applied and found to have an associative value (Winn, 1976; 1977).

The test material (Dwyer and Lamberski, 1977) was a revision of the battery of tests originally published by Dwyer (1972). The materials consist of four 20-item subtests (summed together equal 80 items) assessing hierarchical cognitive knowledge of drawing, identification, terminology, and comprehension. Two forms of the test were prepared, one to follow each of the black/white (B) and color coded (C) learning material formats.

All materials were piloted prior to the present investigation. Test instrument reliability coefficients for data in this study, determined by the Kuder-Richardson formula 20 as being between .74-.88 for the four respective subtests (Lamberski, 1979), compared quite favorably with coefficients found in investigations using Dwyer's original materials (Dwyer, 1972).

Procedure

Participants were randomly assigned to one of four treatment conditions: each treatment represented a crossing of the two levels - black/white (B) or color coded (C) - for each of the independent variables - learning and testing materials. The resulting cells in the design therefore were: B learning and B test materials, B learning but C test materials, C learning and C test materials, and C learning but B test materials. Subjects read the learning booklet immediately after which they were administered a test; six weeks later the identical test was administered to assess delayed retention. Time on the learning task and time on both retention tests were recorded by each subject. There were N = 44 subjects in each treatment condition.

Results and Discussion

Three descriptive indices of instructional efficiency were computed whereby the number of correct items on the immediate or delayed tests were divided by a corresponding time measure. Thus, the dependent variables for subjects in each treatment condition were: the mean achievement score (Table 1) which represents the number of correct items (80 items total) on each respective retention test; the mean learning time (Table 2) which represents how long it took to complete the learning materials (expressed in minutes); and the mean test time (Table 3) which represents how long it took to complete the testing materials (expressed in minutes) on each respective retention test. Thus, the derived mean efficiency values for the three descriptive indices (Tables 4,5, & 6) represent mean number correct per minute on each respective retention test. Data are visually summarized in Figures 1, 2, and 3.

Calculation of the three related efficiency formulas (achievement per unit of time) provided evidence which indicated that while color coded learning materials facilitated student achievement, additional time for acquisition and for retrieval was necessary. Data showed higher efficiencies for immediate test results; this simply reflects that recall was poorer at delayed retention testing. Also, performance or achievement was more efficient when black/white tests were used. Data did not support the hypothesis that the most efficient instructional strategy was to pair color coded learning materials with color coded tests. While the second efficiency index (Figure 2, Table 5) using the test time measure was computed primarily for interest, the first (Figure 1, Table 4) and the third (Figure 3, Table 6) efficiency index values should be viewed as more realistic since learning time or the combination of learning and testing time will normally far outweigh testing time alone.

The findings might mean that color coding facilitated the quality and the quantity of the encoding and the decoding processes but because the discrimination amongst numerous colors was a more time consuming process, the increased encoding and decoding time lowers the efficiency index. However, the data did suggest that color coding of learning materials could be an efficient instructional strategy when coupled with the simpler black/white test. This might be an artifact of the current data though, since testing time was similar to learning time. Certainly, a better situation would be to extend learning time considerably (perhaps 10 fold or more) while holding testing time constant. That should provide a more realistic test of the original efficiency hypothesis.

* * * * * * * * *

References

Berry, L.H. An exploratory study of the relative effectiveness of realistic and non-realistic color in visual instructional materials. Doctoral Dissertation, The Pennsylvania State University, 1974.

Berry, L.H. An investigation of the effectiveness of realistic and non-realistic color in visualized instruction. A paper presented at the AECT Convention, Dallas, TX, 1975.

Berry, L.H. Interactive effects of color realism and learner I.Q. on visualized instruction. A paper presented at the AECT Convention, Anaheim, CA, 1976.

Chute, A.G. An experimental study investigating the comparative effectiveness of a color and a monochrome version of an instructional film presentation on incidental and task-relevant discrimination learning. Doctoral Dissertation, University of Wisconsin at Madison, 1978.

Dwyer, F.M., Jr. A Guide for Improving Visualized Instruction. State College, PA: Learning Services, 1972.

Dwyer, F.M., Jr. Strategies for Improving Visual Learning. State College, PA: Learning Services, 1978.

Dwyer, F.M., Jr. and Lamberski, R.J. The Human Heart: Instructional Unit and Test Materials. 1977. Supplementary volume to Lamberski (1979).

Hinds, L.R. and Dodds, W. Words in color: two experimental studies. Journal of Typographic Research, 1968, 2(1), 43-56.

Kauffman, S.P. and Dwyer, F.M., Jr. Effectiveness of cartoons and photographs in in-service training. California Journal of Educational Research, 1974, 25(4), 197-204.

Lamberski, R.J. An exploratory investigation on the instructional effect of color and black and white cueing on immediate and delayed retention. Master's Thesis, The Pennsylvania State University, 1972.

Lamberski, R.J. An exploratory study in maximizing retention by utilizing black/white and color coding in visualized instruction. P paper presented at the AECT Convention, Dallas, TX, 1975.

Lamberski, R.J. The effect of a verbal and visual color code on self-paced instruction and testing for retention on different tasks. Doctoral Dissertation, The Pennsylvania State University, 1979.

Torkelson, G.M. One quarter century: evolution of theory and research. AV Communication Review, 1978, 24(4), 317-358.

Winn, W.D. The structure of multiple free associations towards black and white pictures and color pictures. AV Communication Review, 1976, 24, 273-293.

Winn, W.D. The effect of the removal of common meaning on the structure of free associations to black and white and color pictures. A paper presented at the AECT Convention, Miami Beach, FL, 1977.

* * * * * * * * *

Contact Addresses

Richard J. Lamberski
Boston Univ. Media Services
765 Commonwealth Ave, Rm 1454
Boston, MA 02215

Dennis M. Roberts
418 Carpenter Building
The Pennsylvania State Univ.
University Park, PA 16802

TABLE 1 - Mean Achievement Scores

Retention	Treatment B/B	B/C	C/C	C/B	
Immediate	52.64	51.34	61.38	58.77	56.03
Delayed	39.91	39.28	44.20	43.48	41.72
	46.28	45.31	52.79	51.13	48.88

TABLE 2 - Mean Learning Time

Treatment B/B	B/C	C/C	C/B	
14.11	14.93	20.18	16.50	16.43

TABLE 3 - Mean Test Time

Retention	Treatment B/B	B/C	C/C	C/B	
Immediate	25.47	26.12	29.12	25.89	26.65
Delayed	22.89	23.08	28.25	24.24	24.62
	24.18	24.60	28.69	25.07	25.64

Table Notes:

B/B = Black/white learning and test materials
B/C = Black/white learning materials but color test materials
C/C = Color learning materials and test materials
C/B = Color learning materials but black/white test materials

Tables 2 and 3: Values represent minutes.

Figure 1 **Efficiency: Achievement/Learning Time**

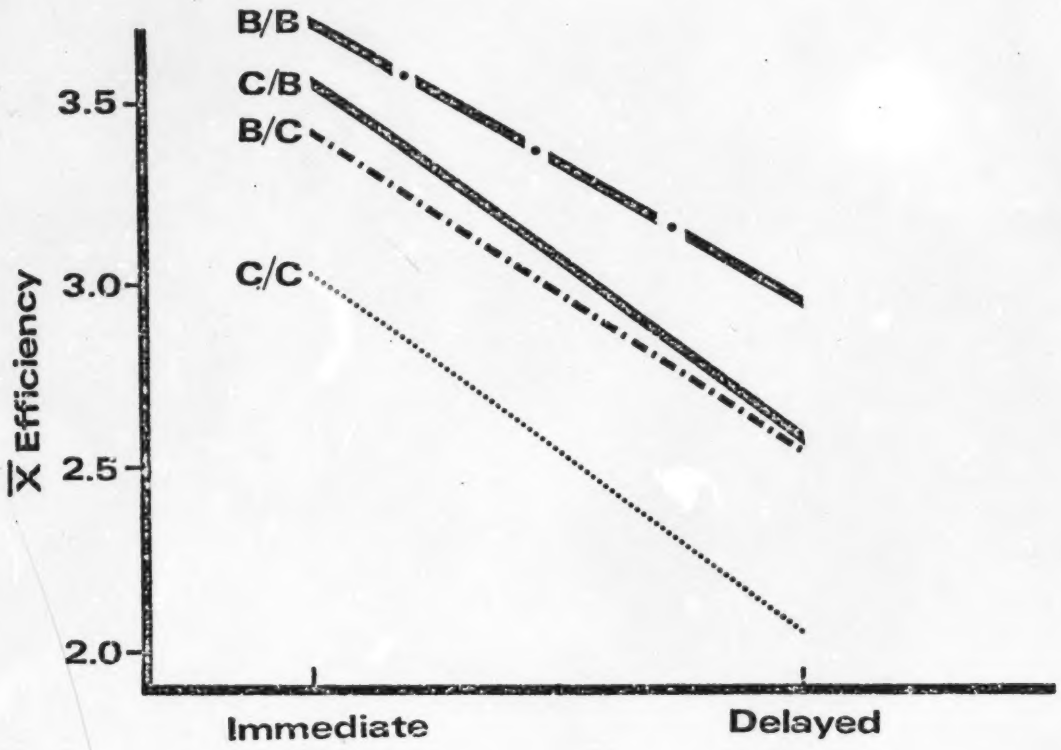

TABLE 4 - Efficiency: Achievement/Learning Time

	Treatment				
Retention	B/B	B/C	C/C	C/B	
Immediate	3.731	3.439	3.042	3.562	3.443
Delayed	2.828	2.631	2.190	2.635	2.571
	3.280	3.035	2.616	3.099	3.007

Note: Values represent mean number correct per minute.

Figure 2 **Efficiency: Achievement/Test Time**

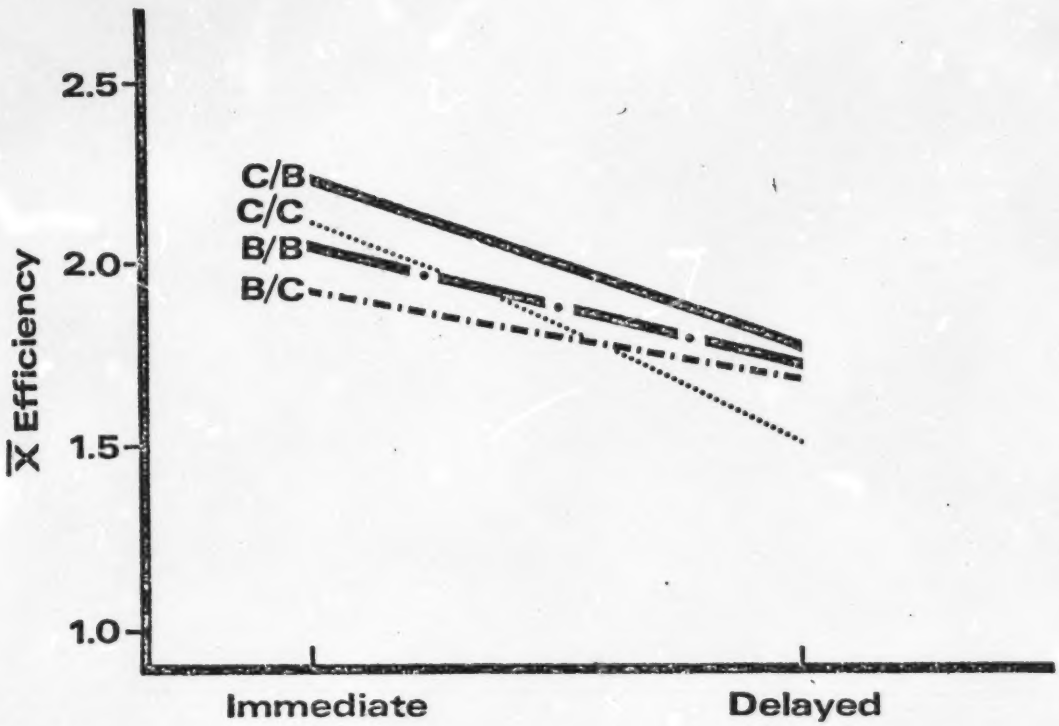

TABLE 5 - Efficiency: Achievement/Test Time

Retention	Treatment B/B	B/C	C/C	C/B	
Immediate	2.067	1.966	2.108	2.270	2.103
Delayed	1.744	1.702	1.565	1.794	1.701
	1.906	1.834	1.837	2.032	1.902

Note: Values represent mean number correct per minute.

Figure 3 **Efficiency: Achievement/Learning & Test Time**

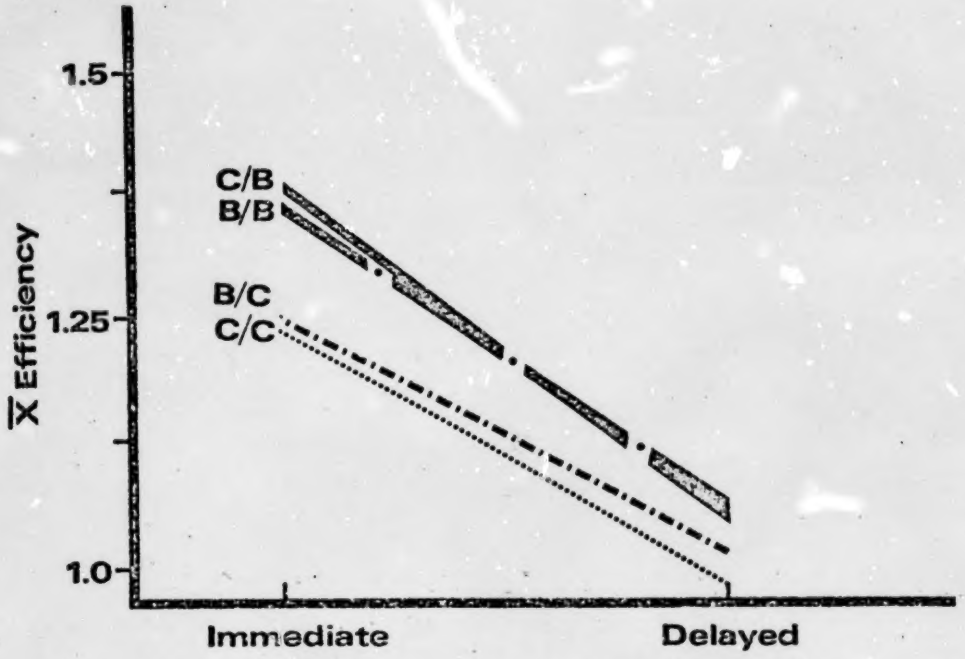

TABLE 6 - Efficiency: Achievement/Learning & Test Time

Retention	Treatment B/B	B/C	C/C	C/B	
Immediate	1.330	1.251	1.245	1.386	1.303
Delayed	1.079	1.033	0.913	1.067	1.023
	1.205	1.142	1.079	1.227	1.163

Note: Values represent mean number correct per minute.